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BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte JOON-SEOP KWAK,
KYO-YEOL LEE,
JAE-HEE CHO,
and SU-HEE CHAE

Appeal 2008-4747
Application 10/673,251
Technology Center 2800

Decided: December 23, 2008

Before CHARLES F. WARREN, CATHERINE Q. TIMM, and MICHAEL P. COLAIANNI, *Administrative Patent Judges*.

TIMM, *Administrative Patent Judge*.

DECISION ON APPEAL

I. STATEMENT OF THE CASE

Appellants appeal under 35 U.S.C. § 134(a) from the Examiner's decision rejecting claims 1-4, 6, 9-27, and 31-35. We have jurisdiction under 35 U.S.C. § 6(b). This case was heard on November 18, 2008.

We AFFIRM-IN-PART.

The invention relates to a method of fabricating semiconductor light-emitting devices, particularly, GaN based Group III-V nitride semiconductor light-emitting devices (Spec. ¶ [0002]). These devices include a number of layers formed on a "high-resistant" substrate such as a sapphire substrate (e.g., Spec. ¶ 17). Independent claims 1 and 23 require a step of dry etching the high-resistant substrate (step (c)). The only other independent claim, claim 12, does not require dry etching. Claim 12 is otherwise similar to claim 1, except that instead of a light-shielding layer, step (d) of claim 12 requires the forming of a light-transmitting layer.

The Examiner rejects claims 1-4, 6, 9-27, and 31-35 under 35 U.S.C. § 103(a) as unpatentable over Kawai (US 6,468,902 B2 issued Oct. 22, 2002) in combination with Nunoue et al. (US 5,905,275 issued May 18, 1999).

In arguing against the rejection, Appellants group claims 1 and 23 (and claims dependent thereon) together as a single group, and argue claim 12 (and claims dependent thereon) separately as a second group (Br. 5-10). In accordance with 37 C.F.R. § 41.37(c)(1)(vii), we select one claim to represent each group. We select claims 1 and 12. [1]

Claims 1 and 12 read as follows:

1. A method for fabricating a light-emitting device, the method comprising:

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[1] Along with the Reply Brief of October 25, 2005, Appellant filed an Amendment to claim 16. There is no indication that the Examiner entered this Amendment (*See* Remand of Aug. 6, 2007, Notice of Non-compliant Brief of Aug. 10, 2007, Ans. of Dec. 13, 2007). Because there is no indication that the Amendment was entered, we do not consider the arguments directed to amended claim 16 (Dec. 26, 2007 Reply Br. 2-3).

(a) sequentially forming a first compound semiconductor layer, an active layer, and a second compound semiconductor layer, which are for inducing light emission, on a high-resistant substrate;

(b) forming a light-transmitting conductive layer on the second compound semiconductor layer;

(c) dry etching a region of the high-resistant substrate using a reaction gas comprising at least $C1_2$ or $BC1_3$ to expose the first compound semiconductor layer; and

(d) forming a light-shielding conductive layer to cover the exposed region of the first compound semiconductor layer.

12. A method for fabricating a light-emitting device, the method comprising:

(a) sequentially forming a first compound semiconductor layer, an active layer, and a second compound semiconductor layer, which are for inducing light emission, on a high-resistant substrate;

(b) forming a light-reflecting conductive layer on the second compound semiconductor layer;

(c) etching a region of the high-resistant substrate to expose the first compound semiconductor layer; and

(d) forming a light-transmitting conductive layer to cover the exposed region of the first compound semiconductor layer.

II. DISPOSITIVE ISSUES

The issues arising in this appeal are:

(A) with respect to claim 1, have Appellants shown a reversible error in the Examiner's finding of a suggestion to dry etch the sapphire substrate of

Kawai as required by step (c) on the basis that Kawai teaches away from such dry etching; and

(B) with respect to claim 12, have Appellants shown reversible error in the Examiner's finding that Nunoue suggests substituting a light-transmitting conductive layer for non-light transmitting layers disclosed in Kawai?

III. PRINCIPLES OF LAW

"The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1739 (2007). However, when the prior art teaches away from a combination, that combination is more likely to be nonobvious. *KSR*, 127 S. Ct. at 1739–40. "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant." *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994). But the degree of "teaching away" depends on the particular facts. *Id.* "Although a reference that teaches away is a significant factor to be considered in determining unobviousness, the nature of the teaching is highly relevant, and must be weighed in substance." *Id.*

IV. FINDINGS OF FACT

The following enumerated findings of fact ("FF") are of particular relevance:

Issue (A)

1. Kawai describes thinning and/or forming a via hole in the sapphire substrate of a GaN FET light-emitting device (col. 3, ll. 27-35).
2. In discussing the prior art, Kawai states that it was known to form via holes in GaAs substrates by wet etching using a sulfuric acid/hydrogen peroxide solution or alkali solution. But, normally, reactive ion etching (RIE) using a mixed gas of CCl_2F_2 and He or ion milling was used (col. 2, ll. 8-20). However, according to Kawai, the techniques used for thinning and forming via holes in GaAs FETs are more difficult to employ in the sapphire substrates of GaN FETs (col. 2, ll. 26-29). Sapphire is much harder than GaAs (col. 2, ll. 29-31). According to Kawai,

> since sapphire is very stable in chemical property, wet etching cannot be used without any effective etchant. As to dry etching by RIE, since its etching rate is as very low as several μm/hr in maximum, and there is no etching mask having a selectivity acceptable for selective etching. Therefore, it is actually impossible to make the via hole with any of these methods.

(col. 2, ll. 37-44.)

3. Kawai suggests forming the via hole by first thinning the sapphire substrate to a thickness of 100 μm or less "for example to a thickness around decades of μm," covering the bottom surface with an etching mask 6 of stacked metal thin film, and wet etching with a solution of phosphoric/sulfuric acid (col. 4, l. 65 to col. 5, l. 11). The etching rate is approximately 10 μm/hr (col. 5, ll. 11-12).

4. Nunoue describes a process of forming a GaN light-emitting device using a sapphire substrate as a support and having n- and p-type electrodes on both the top and bottom surfaces (col. 1, ll. 6-9).
5. Nunoue discloses that:

> the etching rate of sapphire is very low in dry etching or wet etching. For this reason, it is practically difficult to form holes in a sapphire substrate usually having a thickness of 350 μm or more without damaging gallium nitride semiconductor layers.

(col. 1, ll. 61-65.)

6. Nunoue describes etching a 40 μm deep trench 11a in a 350 μm thick sapphire substrate by using an amorphous carbon mask and dry etching with a Cl_2/Ar gas mixture (col. 4, ll. 47-49; Fig. 1a). Nunoue also suggests forming a tapered contact hole 62 in a sapphire substrate 61 by "any appropriate method" although Nunoue does not exemplify dry etching (col. 8, ll. 18-29; Fig. 7a).
7. Appellants, in their Specification, specify using dry etching using Cl_2 or BCl_3, but do not distinguish their dry etching process from those of the prior art (Spec. ¶ [0084]).

Issue (B)

8. Kawai forms a metal film ((Ni or Cr)/Au and Au layers) on the bottom surface of the sapphire substrate to make an electrical connection with a metal layer above the via hole 8 and to radiate heat (col. 5, ll. 28-38; *see also* col. 11, ll. 4-9 and ll. 37-39). Alternatively, Kawai forms a n-side electrode by depositing a Ti/Al film (62) on the bottom surface of the sapphire substrate (col. 13, ll. 45-47; Fig. 14).

9. As shown in Figures 7A-G, in one embodiment Nunoue forms a buried layer 65 to bury the via hole 62 before deposition of layers on the other side of the substrate (col. 8, ll. 40-68). The buried layer 65 may be formed from ZnO, GaN, AlN, GaAlN, etc. (col. 8, ll. 52-56). An n-type electrode 70 may be formed over the buried layer 65 on the bottom side of sapphire substrate 61 when the buried layer is conductive (col. 9, ll. 31-33). Nunoue does not disclose materials for electrode 70 nor specify that the electrode or buried layer be light-transmitting.

V. ANALYSIS

Issue (A)

Nunoue provides evidence that it was known in the art to dry etch sapphire substrates with a Cl_2/Ar gas mixture to obtain 40 μm deep trenches in 350 μm thick substrates (FF 6). Both Kawai and Nunoue recognize that the dry etching rate of sapphire is very low (FF 2, 5). Nunoue states it is difficult to form via holes in 350 μm thick substrates, but Kawai teaches a method of thinning the substrate to levels of below 100 μm before etching (FF 2, 5). The evidence as a whole tends to show that those of ordinary skill in the art understood that it was possible to etch thin substrates of sapphire to form via holes.

Nunoue also discloses a useful mask for the etching procedure, therefore, overcoming the problems noted by Kawai with respect to masking (FF 2, 6).

While Kawai and Nunoue indicate that dry etching sapphire is slow, there is no evidence that Appellants have overcome this problem themselves,

particularly in substrates of the thickness specified by Kawai, i.e., less than 100 μm (FF 7).

Based on the weight of the evidence as a whole, we cannot agree with Appellants that the degree of Kawai's teaching away from dry etching with a CCl_2F_2/He gas mixture (FF 2) is significant enough to overcome the prima facie case of obviousness of dry etching with the Cl_2/Ar gas mixture of Nunoue (FF 6). One of ordinary skill in the art would have used the known dry etching process for its predictable, albeit slow, result of etching of via holes in the thinned substrates of Kawai. While Kawai teaches a different wet etching process as useful, it is well settled that, in a § 103 inquiry, the fact that a different embodiment is taught to be preferred is not controlling, since all disclosures of the prior art must be considered. *Merck & Co. v. Biocraft Labs., Inc.,* 874 F.2d 804, 807 (Fed. Cir. 1989); *In re Heck*, 699 F.2d 1331, 1333 (Fed. Cir. 1983).

With respect to claim 1, Appellants have not shown a reversible error in the Examiner's finding of a suggestion to dry etch the sapphire substrate of Kawai as required by step (c) on the basis that Kawai teaches away from such dry etching.

Issue (B)

Turning to Issue (B), the issue arising for claim 12, we note that the Examiner acknowledges that the metals Kawai deposits on the underside of the sapphire substrate are non-light transmitting (Ans. 6). Kawai deposits the metal layers to make an electrical connection, to radiate heat, or, alternatively, to form an n-side electrode (FF 8). While Nunoue discloses depositing a buried layer 65 on the underside of a sapphire substrate (FF 9), the Examiner provides no reasonable basis for including such a buried layer

in the structure of Kawai. The layer structure of Kawai is built in a different sequence of steps (built before via hole etching) and it is not clear why one of ordinary skill in the art would include a buried layer designed to fill the via hole in preparation for depositing layers Kawai has already deposited.

Appellants have established that the Examiner reversibly erred in finding that Nunoue suggests substituting a light-transmitting conductive layer for non-light transmitting layers disclosed in Kawai.

VI. CONCLUSION

We sustain the rejection of claims 1-4, 6, 9-11, 23-27, and 31-35 under 35 U.S.C. § 103(a). We do not sustain the rejection of claims 12-22 under 35 U.S.C. § 103(a).

VII. DECISION

The decision of the Examiner is affirmed-in-part.

VIII. TIME PERIOD FOR RESPONSE

No time period for taking any subsequent action in connection with this appeal maybe extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED-IN-PART

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BUCHANAN INGERSOLL & ROONEY PC
PO BOX 1404
ALEXANDRIA VA 22313-1404